THE SENSES

- Photoreceptors sense light.
- Mechanoreceptors respond to pressure, movement and tension.
- Thermoreceptors detect changes in temperature.
- Chemoreceptors detect chemicals that are dissolved in fluid.
- Pain receptors (called nociceptors) respond to extreme heat, cold, and pressure, and to chemicals that are released by damaged tissues.
Most of the photoreceptors in the body are found on the retina - in the back wall of the eye. The retina contains two types of photoreceptors:

- **Rods** - detect light intensity and are used in black and white vision. Sensitive to low amounts of light.
- **Cones** - detect color. Need bright light to function.

When light stimulates the rods and cones, they generate a nerve impulse which travels along the optic nerve which carries the impulses to the brain.
HEARING

- **Hair Cells**: specialized cells in the inner ear that contain mechanoreceptors that detect vibrations from sound waves. Hair cells produce action potentials when they are bent.

- The ear collects sounds and funnels them into the **auditory canal** where they vibrate the eardrum (called the **tympanic membrane**). These vibrations are amplified by 3 bones in the inner ear: the **malleus**, **incus**, and **stapes**.
HEARING

• Vibrations in the ear are transferred to the cochlea - a fluid filled canal where the hair cells are located.
• Ear also has organs that regulate balance - this is called the vestibular system.
SMELL AND TASTE

- **Olfactory Cells** - deliver impulses from the nose to the brain.
  - **Olfaction** = smell

- **Papillae** - bumps on the tongue (taste buds) that detect tastes. Generate impulses that are sent to the brain.
  - Your tongue can only detect 5 basic tastes: sweet, sour, salty, bitter, and savory.
Your skin contains receptors that sense touch, temperature, and pain.

- Touch can be detected as pressure, movement, or tension.
- Thermo and nociceptors in the skin detect pain and temperature.
EXIT SLIP

• Why do you think that you can perceive some sounds as loud and others as very soft?
• In the human eye, there are 20 rod cells for every 1 cone cell. How would your vision be different if you had 5 rod cells for every 20 cone cells?
10. What are nociceptors?
11. Which sense involves olfactory cells?
12. What is the charge of a nerve cell at rest?
13. Name the two types of photoreceptors found in the eye.
TWO PARTS OF NERVOUS SYSTEM

- **Central Nervous System (CNS)** - composed of interneurons that interact with other nerves in the body.
  - Receives, interprets, and sends signals to the PNS.

- **Peripheral Nervous System (PNS)** - connects CNS to all organ systems. Uses sensory neurons to detect stimuli from inside and outside your body, and motor neurons to send signals from the CNS to other parts of the body.
CNS

- **Gray Matter** - the collection of neuron cell bodies.
- **White Matter** - the collection of axons. (white in appearance because of myelin sheath)
  - In the brain, gray matter is on the outside and white matter is on the inside. The **spinal cord** has the opposite arrangement.
THE BRAIN

• Contains over **100 billion** neurons.
• Protected by 3 layers of connective tissue called the **meninges**. Between these layers lies a fluid-called **cerebrospinal fluid (CSF)** that helps to cushion the brain against the skull.
• The brain has 3 main structures: the **cerebrum**, the **cerebellum**, and the **brainstem**.
THE CEREBRUM

• **Cerebrum** - interprets signals from your body and forms a response (ex: hunger, thirst, pain, emotion, etc)
  • Divided into 2 halves, called **hemispheres**. Each hemisphere controls the **opposite** side of your body.
  • The two hemispheres are connected by a thick band of nerves in the brain, called the **corpus callosum**.
Left brain expression (Academic)

detail oriented (Looks at parts)
Logical
Sequential
Rational
math and science
can comprehend
Analytical
Objective
uses logic
facts rule
words and language
present and past
knowing
acknowledges
knows object name
reality based
forms strategies
order/pattern perception
practical/planned
safe
cautious

Right brain expression (Creative)

'big picture' oriented (Looks at wholes)
Random
Intuitive
Holistic
philosophy & spiritualism
can 'get it' (the meaning)
Synthesizing
Subjective
uses feeling
imagination rules
symbols and images
present and future
believes
appreciates
knows object function
fantasy based
presents possibilities
spatial perception
impetuous/spontaneous
adventurous
carefree/risk taking

Illustration by: VaXzine
Written and slide design by Dr C Daniels 2008
The outer layer of the cerebrum is called the cerebral cortex- its job is to interpret signals from sensory organs and generate responses. Neurons in the cerebral cortex are arranged in groups that work together to perform specific tasks:

- **Motor Cortex** - helps coordinate movement.
- **Sensory Cortex** - detects touch.
- Scientists divide the cerebral cortex into 4 different lobes, based on their function.
THE CEREBRUM

• **Frontal Lobe**- personality, reasoning and judgment are controlled in this lobe. It also coordinates voluntary movement, and speech production.

• **Parietal Lobe**- the sensory cortex, which deals specifically with touch, is contained in this lobe.

• **Temporal Lobe**- speech interpretation and hearing are functions carried out in this lobe. It also plays a role in memory.

• **Occipital Lobe**- processes visual information.
PHINEAS GAGE
THE CEREBRUM

• Underneath the cerebrum are many smaller areas with different functions.
  • **Limbic System** - involved in learning and emotion - includes the hippocampus and the amygdala.
  • **Thalamus** - sorts information from your sensory organs and passes signals between the spinal cord and other parts of the brain.
  • **Hypothalamus** - gathers information about body temperature, hunger, and thirst - sends signals that help your body adjust and maintain homeostasis.
THE CEREBELLUM AND BRAINSTEM

- **Cerebellum**—coordinates movement and helps maintain posture and balance.

- **Brainstem**—connects the brain to the spinal cord and controls the most basic activities required for life, including breathing and heartbeat. The brainstem has three major parts.
  - **Midbrain**—controls reflexes (ex: changing the size of the pupil to control light entering the eye).
  - **Pons**—regulates breathing and passes signals between brain and spinal cord.
  - **Medulla Oblongata**—connects brain to spinal cord—controls heart function, vomiting, coughing, and swallowing.
Internal structure of the brain

- Spinal cord
- Cerebellum
- Diencephalon
- Pons
- Medulla Oblongata
- Midbrain
- Cerebral hemisphere
WARM UP EXERCISE

14. What is the largest part of the brain called?
15. Name the four lobes of the brain.
16. What is the band that connects the left and right hemisphere of the brain called?
THE SPINAL COLUMN

• The spinal column consists of vertebrae, fluid, meninges, and the spinal cord.
The spine is divided into three main parts:

- **Cervical Spine** - contains 7 vertebrae (C1-C7)
- **Thoracic Spine** - contains 12 vertebrae (T1-T12)
- **Lumbar Spine** - contains 5 vertebrae (L1-L5)
  - **Sacrum** - the back side of the pelvis
  - **Coccyx** - the tailbone
THE SPINAL CORD

- **Reflex Arcs** - only have to cross 2 synapses before producing a response because the signal never has to travel to the brain.
PERIPHERAL NERVOUS SYSTEM

• The peripheral nervous system includes 12 pairs of cranial nerves, and 31 pairs of spinal nerves.

• The Peripheral Nervous System can be broken down into two parts:
  • **Somatic Nervous System** - regulates all voluntary movements. Connects CNS to target organs.
  • **Autonomic Nervous System** - controls automatic functions that you do not have to think about. Works closely with hypothalamus.
The Autonomic Nervous System can be broken down into two parts:

- **Sympathetic Nervous System** - prepares the body for action and stress. Called the “fight or flight” response.
- **Parasympathetic Nervous System** - calms the body and helps the body to conserve energy. Called the “rest and digest” response.
**Parasympathetic Nerves**
"Rest and digest"

- Constrict pupils
- Stimulate saliva
- Slow heartbeat
- Constrict airways
- Stimulate activity of stomach
- Inhibit release of glucose; stimulate gallbladder
- Stimulate activity of intestines
- Contract bladder

**Sympathetic Nerves**
"Fight or flight"

- Dilate pupils
- Inhibit salivation
- Increase heartbeat
- Relax airways
- Inhibit activity of stomach
- Stimulate release of glucose; inhibit gallbladder
- Inhibit activity of intestines
- Secrete epinephrine and norepinephrine
- Relax bladder
THE RESPIRATORY SYSTEM

- **Function**: to exchange O₂ and CO₂ between the blood, air, and tissues.
- Blood carries O₂ from the lungs to the body’s tissues and carries CO₂ (a waste product of cell respiration) in the opposite direction.
THE FLOW OF AIR

- **Nose or Mouth**
- **Pharynx** (or throat)- passageway for both air and food
- **Trachea** (or windpipe)
  - The trachea is covered by the epiglottis to keep food from entering your windpipe when you swallow.
- **Larynx** - (at the top of trachea) contains the vocal cords.
- **Bronchi**- two large passageways that lead into each of the lungs where they subdivide into smaller bronchi, then to smaller bronchioles.
- **Alveoli**- tiny air sacs surrounded by capillaries
GAS EXCHANGE

- Alveoli provide a huge surface area for gas exchange.
- $O_2$ diffuses across the capillaries into the blood. $CO_2$ diffuses in the opposite direction.
- $O_2$ binds to hemoglobin in the blood and carries it to the rest of the cells in the body.
CILIA AND MUCUS

- The respiratory passageways are lined with cilia and mucus to help keep lungs clean and efficiently exchanging gas.
BREATHING

- **Pleural Membranes** - two sacs that seal the lungs inside the chest cavity.
- **Diaphragm** - large muscle at the bottom of the chest cavity.
  - **Inhale** - diaphragm contracts, rib cage rises. Expands volume of chest cavity. Air rushes into the lungs.
  - **Exhale** - diaphragm relaxes, rib cage lowers. Air rushes back out of the lungs.
Breathing is controlled by a part of the brain called the medulla oblongata, which monitors the amount of CO$_2$ in the blood. These levels signal nerve impulses that cause the diaphragm to contract, bringing air into the lungs.
Why can’t you breathe through your mouth while swallowing food? What would happen if you could do this?

Human lungs have a total surface area of 750 square feet, about the same as one side of a tennis court.
17. What are the air sacs that aid in gas exchange called?

18. Which part of the brain regulates breathing- by monitoring CO$_2$ and O$_2$ levels?

19. What structure keeps food from going down your windpipe?
The circulatory system is made of 3 main parts:

- **Heart** - a muscular pump that keeps blood moving to every part of your body.
- **Blood** - the average adult contains about 5 liters of blood. Your blood makes a round trip from your heart to body tissues and back to the heart every 60 seconds.
- **Blood Vessels** - in our circulatory system, blood stays within vessels, so it is considered to be a closed system.
  - **Arteries** - carry blood away from the heart to the rest of the body.
  - **Veins** - blood vessels that carry blood from the rest of the body back to the heart.
  - **Capillaries** - tiny blood vessels that transport blood to and from cells of the body. Connect arteries and veins.
HOMEOSTASIS AND CIRCULATION

• The circulatory system collects waste produced in the body and delivers it to the liver and kidneys to be filtered out of the body.
• The circulatory system helps maintain body temperature by distributing heat produced by muscles and internal organs.
**GAS EXCHANGE**

- Red blood cells pick up oxygen in the lungs (specifically the alveoli) and deliver it to all of the cells in the body.
- Oxygen specifically binds to an iron-rich protein in the blood, called **hemoglobin**.
  - Each molecule of hemoglobin binds with 4 $O_2$ molecules.
  - The iron in the hemoglobin gives blood its reddish color.
RESPIRATORY DISEASES

- **Emphysema** - caused by smoking, destroys alveoli, which reduces surface area for gas exchange.
- **Asthma** - bronchioles constrict due to muscle spasms. May be triggered by allergies, stress, smoke, exercise, or other chemicals.
- **Cystic Fibrosis** - lungs produce thick sticky mucus that blocks airways and allows for infections.
If a person has a low blood pressure, how will this affect their overall body temperature? Explain.
20. What are the three major parts of the circulatory system?
21. Explain the differences in the three types of blood vessels.
22. What two organs help filter waste from the blood?
23. What component of blood gives it a reddish appearance?
HEART SOUNDS

• **Lub-Dub (Shhh)**
  - **Lub** - the sound that occurs when the valves between the upper and lower chambers of the heart snap shut.
  - **Dub** - the sounds made by valves closing the two arteries that carry blood out of the heart.
  - **Shhh** - the sound made by a heart with a leaky valve.
STRUCTURE OF THE HEART

- The heart is divided into 4 main chambers:
  - **Atrium** (right and left) - the smaller of the chambers
  - **Ventricles** (right and left) - the larger of the chambers
    - Separated by the **septum** - a thick wall of tissue.
- **Valves** - flaps of tissue that prevent blood from flowing backward.
  - They **open** when the atria or ventricles **contract**, and **close** when they **relax**.
THE HEARTBEAT

• The heartbeat is regulated by the **sinoatrial (SA) node**, which is known as the heart’s **pacemaker**. The cells of this node (located in the **right atrium**) generate a nerve impulse that spreads through both atria, causing them to contract, sending a rush of blood down through the right and left ventricles.

• The nerve impulse moves along the neural pathway and stimulates the **atrioventricular (AV) node** (located in the wall of the **right ventricle**) which causes both ventricles to contract simultaneously, pushing the blood upward into the aorta and pulmonary vein.
THE FLOW OF BLOOD

• Oxygen-poor blood enters the **right atrium**. SA node signals atria to contract, and blood flows into **right ventricle** and to the **pulmonary artery** (which goes to the **lungs**).
  - Blood enters lungs where CO₂ diffuses into the alveoli and O₂ diffuses into the blood.
• Oxygen-rich blood returns to the heart through the **pulmonary vein** and enters **left atrium**. When the atria contract, blood is pumped into **left ventricle**. When the ventricles contract, blood is pumped up, into the **aorta** and is circulated to the rest of the **body tissues**.
• After oxygen has been delivered to all the cells, oxygen-poor blood returns through the **veins** to the heart, and it starts again.
PATHWAYS OF BLOOD

- Circulating blood follows two separate pathways that meet at the heart:
  - **Pulmonary Circulation** - occurs only between the heart and the lungs. Functions to carry oxygen-poor blood to the lungs, where it picks up O₂ and expels CO₂ and carries oxygen-rich blood back to the heart.
  - **Systemic Circulation** - occurs between the heart and the rest of the body, except for the lungs. Functions to carry oxygen-rich blood to all cells and transport oxygen-poor blood back to the heart. Begins when blood leaves the left ventricle.
WARM UP EXERCISE

24. Starting with the vena cava, how does the blood flow through the heart?
25. What is important about the SA Node?
26. What are the two pathways of the blood?
CIRCULATION AND BLOOD PRESSURE

- **Blood Pressure** - the force with which blood pushes against the wall of an artery.
  - A healthy, resting blood pressure of a young adult is around 120/70 mmHg
  - The top number is known as the **systolic pressure** - the pressure in the artery when the left ventricle **contracts**.
  - The bottom number is the **diastolic pressure** - the pressure in the artery when the left ventricle **relaxes**.
CIRCULATORY DISEASES

- **Hypertension** - permanently high blood pressure can lead to a heart attack or stroke.
  - **Heart Attack** - when arteries to the heart muscle are damaged or blocked.
  - **Stroke** - blood flow to the brain is interrupted.
- **Atherosclerosis** - blood flow is partially or fully blocked by a sticky material, called plaque, that collects on the walls of the arteries.
COMPONENTS OF BLOOD

- **Plasma** - straw colored fluid in which the blood cells are suspended.
- **Platelets** - cell fragments that help in blood clotting.
- **Red Blood Cells** - functions to transport $O_2$ to cells and carry $CO_2$ away from them.
  - Have a lifespan of ~120 days. Red blood cells are unique because they have no nucleus.
COMPONENTS OF BLOOD

- **White Blood Cells** - defend the body against infection and remove foreign and dead cells.
  - WBC’s are part of **immune** and **circulatory** systems because they can leave the blood vessels to fight infection.
  - Platelets, red blood cells, and white blood cells are manufactured in the **bone marrow**.
PLATELETS AND BLOOD CLOTTING

• Clotting Disorders
  • **Hemophilia** - individuals lack specific clotting factors and bleed freely.
  • Other individuals form clots inside their blood vessels (called a *thrombus*). This can lead to pain, heart attack, or stroke.
THROMBOSIS
EXIT SLIP

• Explain how the blood helps in maintaining homeostasis.
• How does narrowing of the arteries effect blood flow and blood pressure? Explain.
27. Name the major components of blood, and briefly describe their functions.
28. What do the two numbers in a blood pressure represent?
29. What is a healthy blood pressure?
PATHOGENS AND HUMAN ILLNESS

• **Germ Theory**- proposed that specific microorganisms cause infectious disease.
  • This was proposed by Louis Pasteur in the 1850s and tested by Joseph Lister and Robert Koch.
• These diseases causing agents are called **pathogens**.
  • These can be bacteria, viruses, fungi, protists, parasites, etc.
  • Many pathogens are transmitted by a **vector**- another organism that carries and transmits the disease.
**Immune System**

- **Immune System** - fights off infection and pathogens.
  - Relies on physical barriers to keep pathogens out. This is called **innate immunity**.
  - Another type of immunity relies on specialized cells to fight pathogens that do breach the physical barriers. This is called **acquired immunity**.

- **Phagocytes** - destroy pathogens by engulfing them and breaking them down. (innate immunity)
IMMUNE SYSTEM

• White blood cells, called lymphocytes, help to initiate specific immune responses. There are two main types of white blood cells:
  • **T Cells** - destroys body cells that are infected with pathogens.
  • **B Cells** - inactivate pathogens that have not yet infected cells. They do this through the use of **antibodies** - proteins that make pathogens ineffective.
PASSIVE AND ACTIVE IMMUNITY

• **Passive Immunity**- occurs without the body undergoing an immune response.
  • Transferred from mother to child during through the *placenta*, and through *breast milk*.

• **Active Immunity**- occurs when your body produces a response to a specific pathogen.
  • Keeps you from getting the same virus twice.
  • *Vaccinations* are an example of active and passive immunity.
EXIT SLIP

• Name some ways that pathogens can be spread.

• If a person had a disease that prevented lymphocytes from maturing, how would the immune system’s response to infection change?
WARM UP EXERCISE

30. What does germ theory describe?
31. Explain the major difference in T cells and B cells.
32. What is a phagocyte?
33. What is the difference in active and passive immunity?
INFLAMMATION

- **Inflammation** - a nonspecific response characterized by swelling, redness, itching, and increased temperature at the affected site.
  - Occurs when a pathogen enters the body or when the tissues become **damaged**.
  - In an inflammatory response, **mast cells** release chemicals called **histamines** to respond to the invasion. This causes blood vessels to **dilate**.
INFLAMMATORY RESPONSE

- Bacteria
- Chemical alarm signals
- Blood vessel
- Phagocytes
ANTIGENS AND MEMORY CELLS

• **Antigens** - markers on the surface of pathogens that help the immune system to identify a foreign cell.

• **Memory Cells** - specialized T cells and B cells that are stored in the body to fight a specific antigen in a second attack.
TYPES OF IMMUNE RESPONSE

- There are two types of immune response:
  - **Humoral Immunity** - activated by B cells - depends on the production of antibodies to fight pathogens.
    - B cell recognizes foreign cell for which it is specific to. B cell binds to the antigen on the foreign cell.
    - T cell binds to the B cell, activating it.
    - Once activated, the B cell divides into active B cells, which produce an army of antibodies to fight the pathogen, by inactivating it, and memory B cells, which are stored to fight the same pathogen in a future encounter.
HUMORAL IMMUNITY

1. Antigen-presenting cell
   - Pathogen Antigen fragment
   - Class II MHC molecule
   - Accessory protein
   - Helper T cell

2. B cell
   - Activated helper T cell
   - Cytokines
   - Plasma cells
   - Secreted antibodies

3. Memory B cells
**TYPES OF IMMUNE RESPONSE**

- **Cellular Immunity** - activated by T cells - depends on T cells attacking infected cells by releasing a toxic chemical that leads to destruction of the pathogen.
  - A phagocyte recognizes a foreign invader and engulfs it. The invader’s antigens are removed and the phagocyte displays them on its surface. This is called an antigen presenting cell.
  - A T cell specific for that antigen binds to the cell, and releases molecules that lead to the death of the pathogenic cell.
  - The T cell now divides into two types of T cells: active (cytotoxic) T cells and memory T cells. The active cells go on to destroy other infected cells, and the memory cells lay stored in the body for future attacks by the same pathogen.
CELL MEDIATED IMMUNITY

[Diagram of Cell Mediated Immunity]

1. Cytotoxic T cell
   - Accessory protein
   - Class I MHC molecule
   - Infected cell
   - Antigen fragment

2. Perforin
   - Pore
   - Antigen fragment
   - Granzymes

3. Released cytotoxic T cell
   - Dying infected cell
ANTIBODIES
34. What is an antigen?
35. Which type of cells are involved in cell-mediated immunity, and which are in humoral immunity?
36. Which type of immunity results in the production of antibodies?
37. Why are memory cells useful?
FOREIGN TISSUES

- **Tissue Rejection** - antigen receptors on the surface of the cell make antibodies against the donor tissue.
  - In order to help eliminate this, patients take immunosuppressants prior to surgery. Unfortunately, this lowers their ability to fight any other infections.
ALLERGIES AND ANAPHYLAXIS

- **Allergies** - a hypersensitivity to a normally harmless antigen.
  - Caused by **allergens** - an antigen that causes an allergic reaction. The immune system produces **antibodies** in response to these allergens.
  - When allergens enter the body, specialized cells release **histamine** which causes an **inflammatory response**.

- **Anaphylaxis** - immune system releases large amounts of histamine which causes airways to tighten.
  - From an allergic reaction to **food**, **bee stings**, **medicine**, etc.
**Autoimmune Disease** occurs when the immune system cannot differentiate between the body’s healthy and unhealthy cells.

- Examples: Rheumatoid Arthritis, Type 1 Diabetes, Multiple Sclerosis, Graves’ Disease
HIV/AIDS

- **HIV and AIDS** - (Human Immunodeficiency Virus) (Acquired Immune Deficiency Syndrome) - caused by a retrovirus that infects T cells.
LYMPHATIC SYSTEM

- **Lymphatic System** distributes nutrients, absorbs excess fluid, fights disease, and carry wastes away from cells.

- The lymphatic system collects excess fluid that leaks out of blood capillaries into the space between the cells (called **interstitial fluid**). This fluid is absorbed into lymphatic capillaries where it becomes known as **lymph**. Lymph is filtered from the vessels at areas called **lymph nodes**, where trapped particles are filtered out. Vessels then return the lymph to the circulatory system. The lymphatic waste is filtered through the **spleen**.
EXIT SLIP

- Why would someone experiencing anaphylaxis need to receive medicine through an injection rather than swallowing a pill?